

# Fort Detrick, Maryland

## Crash Location Enhancement Study



*prepared for*  
**Military Traffic Management Command**  
**Transportation Engineering Agency**  
Corps of Engineers, Norfolk Division

**June 2000**

*prepared by*  
 **Gannett Fleming**

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## EXECUTIVE SUMMARY

### Scope

The Military Traffic Management Command Transportation Engineering Agency (MTMCTEA), through Gannett Fleming, conducted a crash location enhancement study of Fort Detrick, Maryland from 14-18 February 1999. The main objective of the study was to investigate and make recommendations to improve traffic operations and safety.

### Findings and Recommendations

This report analyzed two intersections at Fort Detrick:

- Military Road, 7<sup>th</sup> Street, and Ditto Avenue (Main Gate)
- Ditto Avenue and Porter Street

A safety audit was also conducted of primary and secondary installation roadways. The focus of the audit was to evaluate traffic control devices and to identify potential roadside safety hazards.

LOCATION	FINDINGS	RECOMMENDATIONS AND COST
<b>Military Road, 7<sup>th</sup> Street, and Ditto Avenue</b>	<ul style="list-style-type: none"> <li>• January 1999 to December 1999 - 3 crashes, 0 injuries or fatalities</li> <li>• Improper lane use during entry to the base</li> <li>• Poor advanced lane use control signing on 7<sup>th</sup> Street</li> <li>• Queuing of vehicles to Porter Street along Ditto Avenue during the PM peak hour</li> <li>• Numerous near miss crashes</li> <li>• AM and Midday peak hour traffic appear to operate smoothly and the results of the modeling were consistent</li> <li>• Street lighting is adequate</li> <li>• Truck traffic does not significantly affect the operation of the intersection</li> <li>• Signing and pavement marking deficiencies</li> <li>• Does not meet peak hour volume warrant for signalization</li> </ul>	<ul style="list-style-type: none"> <li>• Revise advanced signing on 7<sup>th</sup> Street and Military Road - \$8,000</li> <li>• Revise gate operation - \$16,000</li> <li>• Remove stop condition on Ditto Avenue</li> <li>• Provide separate left turn lane on 7<sup>th</sup> Street approach - \$1,100</li> <li>• Replace the overhead lane use control signs and the stop sign on the Military Road approach. Replace any other roadway signs that have lost their nighttime reflectivity on the approaches to the intersection as routine maintenance - \$1,000</li> <li>• Replace the existing Ditto Avenue approach pavement markings (symbols, legends, lane line) with thermoplastic pavement markings. Thermoplastic pavement markings will provide greater visibility, reflectivity, and longevity needed for a twenty-four hour gate - \$1,000</li> </ul>

LOCATION	FINDINGS	RECOMMENDATIONS AND COST
<b>Ditto Avenue and Porter Street</b>	<ul style="list-style-type: none"> <li>January 1999 to December 1999 - 4 crashes, no injuries or fatalities</li> <li>Congested in PM Peak due to stacking of vehicles from the Military/7<sup>th</sup>/Ditto intersection</li> <li>Removal of the stop condition on Ditto Street at Military and 7<sup>th</sup> Street reduces the total peak hour delay at this intersection from 107.3 hours to 1.8 hours of delay</li> <li>The 3-way placard supplementing the stop signs are not standard</li> <li>Many of the pavement markings are faded and may be difficult to view under wet conditions</li> <li>Does not meet peak hour volume warrant for signalization</li> </ul>	<ul style="list-style-type: none"> <li>Install permanent concrete channelizing island on the eastbound approach - \$3,400</li> <li>Install ADA ramp on the northern crosswalk on the northeast corner of the intersection - \$1,000</li> <li>Install No Pedestrian Crossing signs, R9-3a, to the south side of the intersection - \$300</li> <li>Replace stop signs and 3-way placards on all approaches - \$1,000</li> <li>Replace worn pavement markings on all approaches to the intersection. The markings include word markings, symbol markings, stop bars, lane lines, and centerlines. The materials and application of the markings should meet state or local specifications to ensure proper reflectivity and durability - \$1,000</li> </ul>

### Further Assistance

Findings and recommendations in this report are based on analyses of data obtained during the field survey, review of crash reports provided by the Provost Marshal's Office (PMO), and through conversations with personnel at Fort Detrick. Questions regarding the recommendations in this report should be referred to MTMCTEA.

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## FINDINGS AND RECOMMENDATIONS

### Methodology

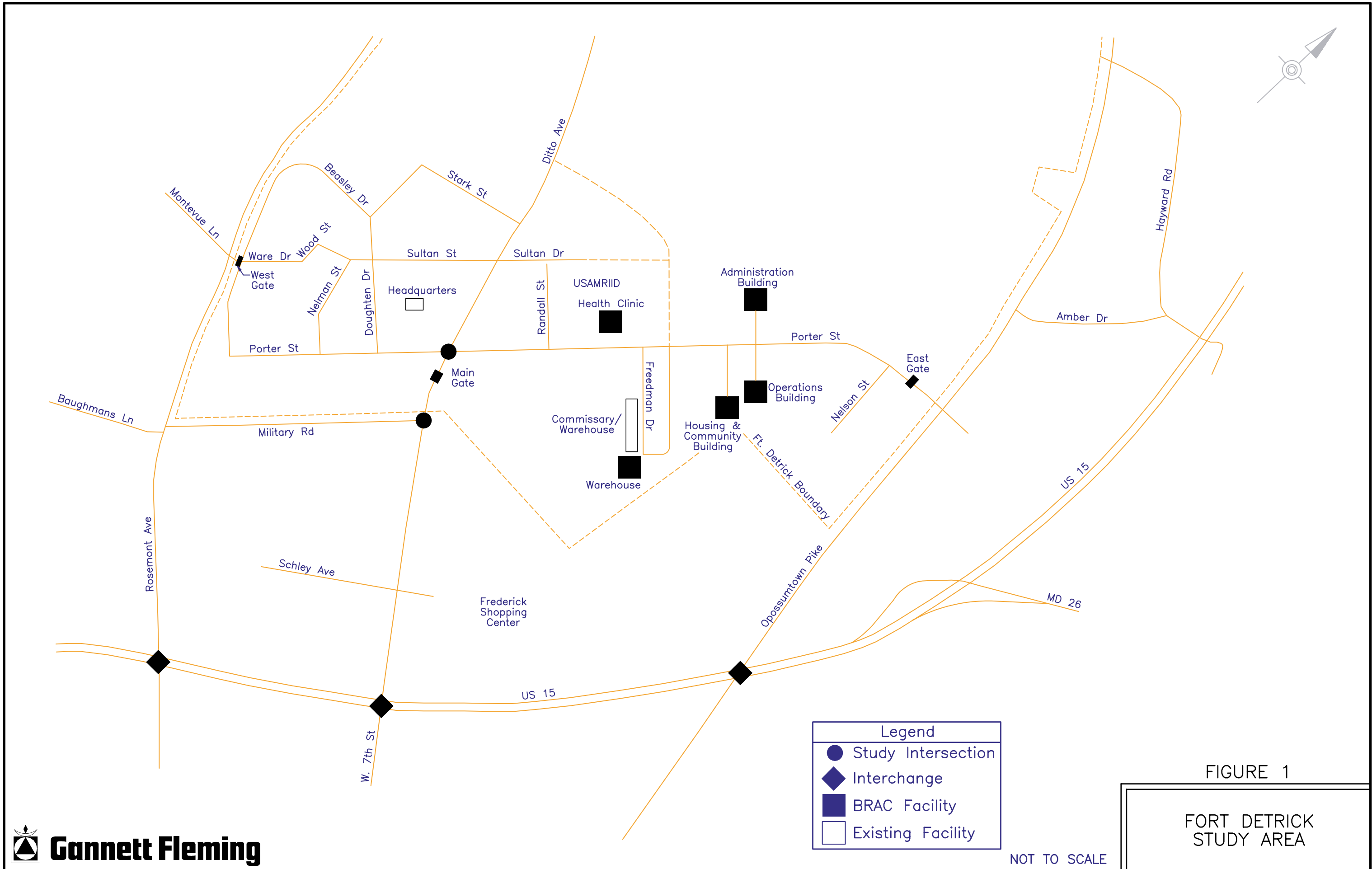
This report analyzed two intersections at Fort Detrick:

- Military Road, 7<sup>th</sup> Street, and Ditto Avenue (Main Gate)
- Ditto Avenue and Porter Street

Safety audits were conducted on all primary and secondary installation roadways. The focus of the audit was to evaluate traffic control devices and to identify potential roadside safety hazards. The study area is presented in Figure 1.

The study team performed the following tasks to identify and resolve traffic and safety concerns at the study locations:

1. **Data Collection** – Morning, mid-day, and evening peak-hour turning movement counts were conducted at the study intersections. Safety audits were conducted on all primary and secondary installation roadways. Additionally, photographs were taken and condition diagrams were prepared.
2. **Field Investigations** – Several field observations were conducted to assess traffic flow and safety operations at study intersections. Traffic operations were monitored during critical time periods to help identify safety deficiencies.
3. **Analysis and Problem Identification** – Data was analyzed using traffic engineering and safety standards from the following sources:
  - *Highway Capacity Manual* (HCM), Transportation Research Board Special Report 209, 1994 and 1997
  - Highway Capacity Software, developed by FHWA and distributed by McTrans
  - *Manual on Uniform Traffic Control Devices (MUTCD)*, FHWA, 1988
  - *A Policy on Geometric Design of Highways and Streets*, American Association of State Highway and Transportation Officials (AASHTO), 1994
  - *Roadside Design Guide*, American Association of State Highway and Transportation Officials (AASHTO), 1996
  - *Traffic Engineering Handbook*, 4<sup>th</sup> Edition, ITE, 1992
  - *Traffic Planning Handbook*, ITE, 1992
  - *Synchro 4.0* Software, distributed by Trafficware
  - *SimTraffic* Software, distributed by Trafficware
  - *MTMCTEA Pamphlet 55-10, Traffic Engineering for Better Roads*, 1985
  - *MTMCTEA Pamphlet 55-14, Traffic Engineering for Better Signs and Markings*, 1985 and 1988
  - *MTMCTEA Pamphlet 55-17, Better Military Traffic Engineering*, 1987





Traffic volumes and lane configurations were used in *Synchro* and *SimTraffic* to model the existing and proposed conditions of the study intersections. Measures of effectiveness such as delay per vehicle, total delay, and fuel used were calculated for comparison purposes. The model also provided information regarding queuing distances.

4. **Recommendations** - From the accident reports, traffic volumes, computer modeling, and field observations, recommendations were developed for each location studied.

It should be noted that, MTMCTEA publicizes highway safety because of the many deaths and injuries that occur on military installations each year. Highway accidents and their severity are caused by one or more of the highway system elements: the roadway, the vehicle, and/or the driver. Many times, law enforcement officials tend to blame accidents directly on the driver. Even if the driver was at fault, did the road or roadside environment contribute to the severity of injuries or property damage costs? Too often the driver takes the blame, while other causative factors remain hidden. The driver is expected to compensate for inadequate highway design and control measures in his/her driving tasks. Transportation engineers know a definite correlation exists between accidents or accident severity and substandard design or inadequate control measures. Accident causes and their destruction intensity must be clearly defined and related to the highway system elements.

Often fatal and serious injury accidents occur because motorists impact highway hazards. Even though the accident cause is listed as driver error such as running off the road, speeding, driving under the influence (medicinal drugs), driving while intoxicated, falling asleep, etc., there are contributory factors surrounding an accident that affect the severity. In other words, the highway features are not forgiving or crashworthy. In the case of traffic control devices, they may be unnecessary, non-standard, or confusing.

## Intersection of Military Road, 7<sup>th</sup> Street and Ditto Avenue (Main Gate)

### Existing Conditions:

- **Control:** Unsignalized Intersection with 3-way STOP control on Military Road and Ditto Avenue; Free flow on 7<sup>th</sup> Street.
- **Speed Limit:** 25 mph on all approaches.
- **Roadside Hazards:** None.
- **Sight-distance Restrictions:** Business and advertisement sign in the southwest corner of the intersection restricts sight distance for vehicles attempting to enter the intersection from Military Road and Ditto Avenue.
- **Street Lighting:** Northeast, northwest, and southwest quadrants.
- **Morning Peak-hour Traffic:** Total intersection volume of 1,092 vehicles (refer to Figure 4 for turning movement counts).
- **Mid-day Peak-hour Traffic:** Total intersection volume of 1,322 vehicles (refer to Figure 4 for turning movement counts).
- **Evening Peak-hour Traffic:** Total intersection volume of 1,451 vehicles (refer to Figure 4 for turning movement counts).
- **Pedestrian Level:** Minimal (less than 2 crossings per hour).
- **Restrictions:** None.
- **One-year (January 1999 - December 1999) Crash History:** 3 crashes, no injuries or fatalities.



Figure 2. Intersection of Military Road, 7<sup>th</sup> Street and Ditto Avenue (Main Gate – northward view).



Figure 3. Sight distance restriction at Military Road, 7<sup>th</sup> Street and Ditto Avenue (southward view)

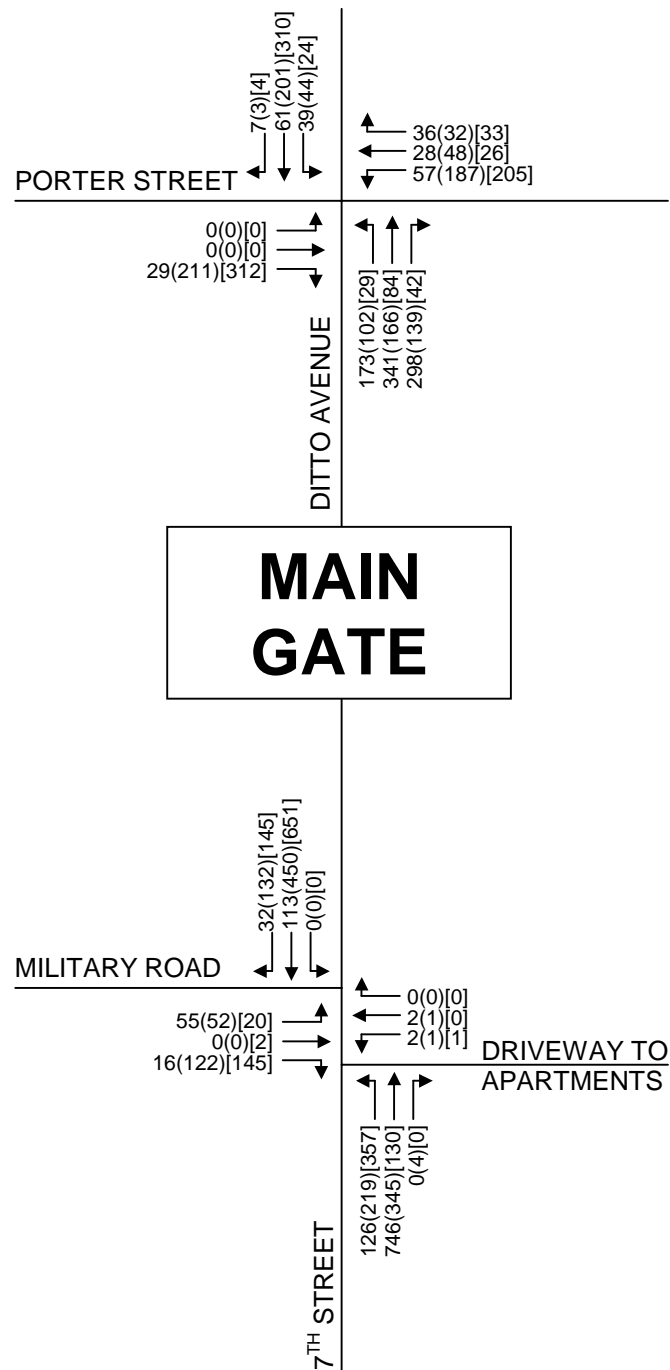


Figure 4. Peak Hour Traffic Volumes at the Study Intersections.

### **Discussion and Recommendations:**

The intersection of Military Road, 7<sup>th</sup> Street and Ditto Avenue is a four-legged, skewed unsignalized intersection and acts as the “Main Gate” to the installation. A driveway to apartments on the southeast corner of the intersection forms the fourth leg of the intersection.

Military Road is a curbed-section, two-lane, two-way collector roadway connecting 7<sup>th</sup> Street to Rosemont Avenue. It is the west leg of the intersection and provides an alternate route to U.S. Route 15 for local traffic traveling between the 7<sup>th</sup> Street interchange and the Rosemont Avenue interchange. 7<sup>th</sup> Street is a curbed-section, three-lane undivided collector roadway to the south of the intersection and the primary route for accessing Fort Detrick’s Main Gate. Connecting Fort Detrick to U.S. Route 15, it is the posted route for motorists traveling on U.S. Route 15 to access the installation. Both Military Road and 7<sup>th</sup> Street are under the jurisdiction of the City of Frederick. Ditto Avenue is the north leg of the intersection and is located internal to the installation. It is a curbed-section roadway with four lanes, two lanes exiting and two lanes entering Fort Detrick. The lanes are divided by a median containing the sentry station.

The intersection is stop-controlled on three of the four approaches. Only the 7<sup>th</sup> Street approach is free-flowing. During peak hours, police officers will intermittently direct traffic at the intersection. Due to the gate’s close proximity to the intersection, if trucks or visitors do not use the proper lane, traffic will queue into the intersection along 7<sup>th</sup> Street (Figure 5). In addition, the following deficiencies were identified:



**Figure 5. Queue from Main Gate stacking into the intersection during AM Peak (southward view).**

- **Intersection Operation**

Due to the unusual operation of the intersection and its direct impact on the adjacent intersection at Ditto Avenue and Porter Street, the intersections were analyzed as a network using *Synchro* and *SimTraffic*. The results of the analyses are contained in Appendix A. The results are consistent with field observations. During the PM peak hour, traffic exiting the installation on Ditto Avenue queues to and through the intersection of Porter Street.

To improve the operation of the intersection, the stop control on Ditto Avenue exiting the post was removed and a separate left turn lane was added to the 7<sup>th</sup> Street approach. As shown in Appendix A, the improvements provided a substantial reduction in the delay at the intersection.

The skew of the intersection also creates challenges for vehicles stopped on Ditto Avenue and on Military Road looking for a gap to enter the intersection. First, it is difficult to view approaching vehicles on 7<sup>th</sup> Street. The sight distance deficiency is compounded due to a ground mounted business sign in the southwest corner of the intersection. Further, many approaching motorists on 7<sup>th</sup> Street do not use their turn signal to indicate they are turning left onto Military Road. It was observed that adequate gaps were lost or near crashes occurred due to this driver error. The addition of a separate left-turn lane on the 7<sup>th</sup> Street will better align the intersection and will clearly delineate those motorists intending on turning left.

- **Signing, Marking, and Lighting**

The lane use approach signing along 7<sup>th</sup> Street is poor due to the size, color, and font of the lettering. The signing is critical to the operation of the gate and intersection. Figure 7 is a concept plan for signing the 7<sup>th</sup> Street approach to the installation.

The lane use control signs on Military Road do not specify access to Fort Detrick. Use of a post-mounted sign, “Fort Detrick Next Left”, may be helpful to motorists unfamiliar with the area.



**Figure 6. Existing 7<sup>th</sup> Street approach signing (northward view).**

The pavement markings along the Ditto Avenue approach are faded and may not be visible in wet or nighttime conditions. While few pedestrians were noted during data collection, adequate pedestrian facilities should be provided. According to the MUTCD, crosswalks should be at least 6 feet wide with at least 6-inch wide edge lines.

Based on field observations, data collection, and discussion with field personnel, the lighting seems adequate for detecting decals and traversing the intersection safely.

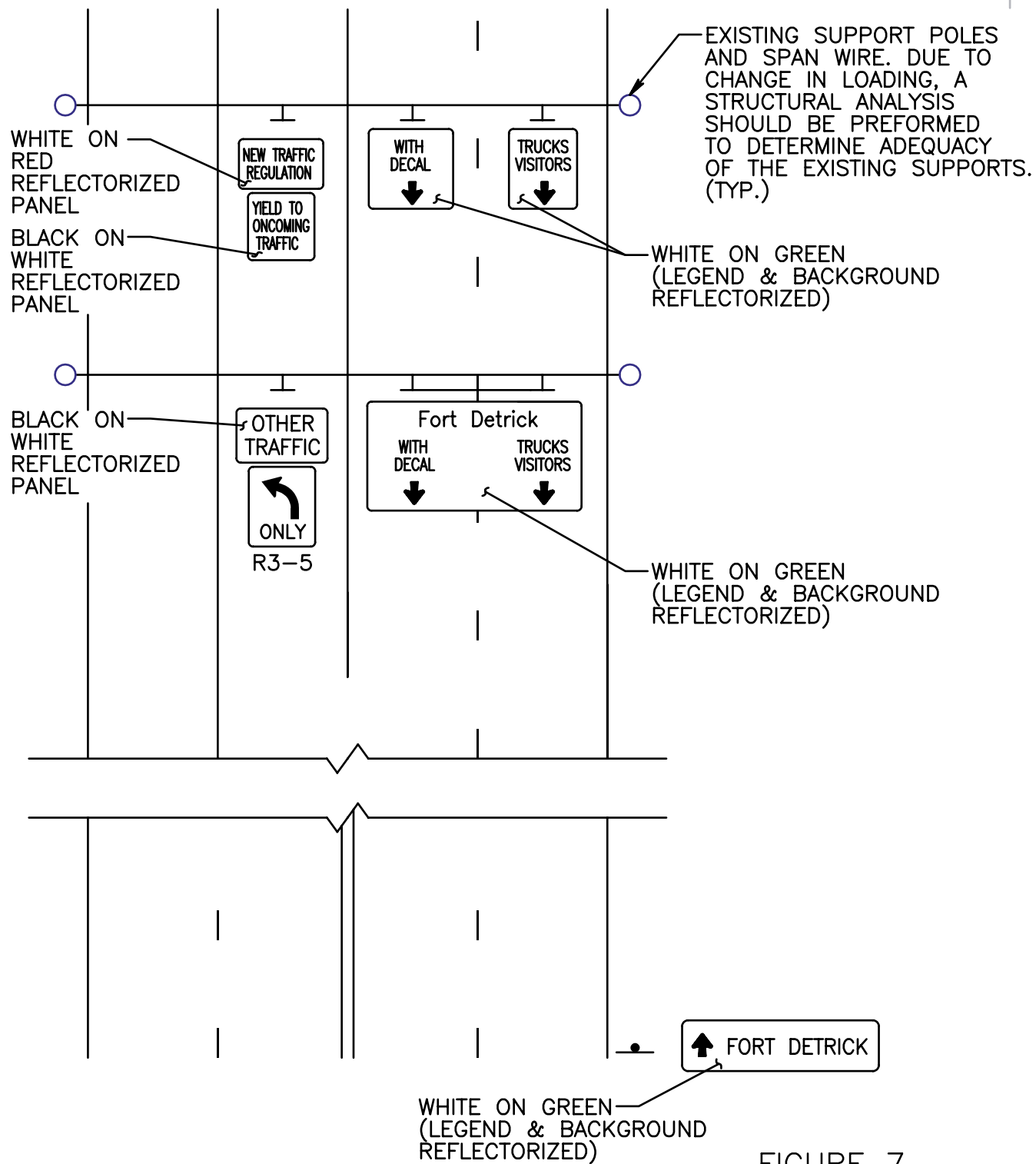


FIGURE 7

PROPOSED 7th STREET  
APPROACH SIGNING



**Gannett Fleming**

- **Gate Operation**

Only three minor crashes have occurred at the intersection. However, through discussions with military personnel and observation of the existing gate operations, it is evident that numerous near misses and a serious queuing problem exist. The longer the queues and delays at the gate, the greater the likelihood of crashes. As vehicles back up from the gate into the intersection, the probability of crashes becomes even greater.

There are three factors directly responsible for this problem:

1. The number of vehicles that can be processed per unit time
2. The amount of storage available for vehicles
3. Volume of traffic entering the gate.

The Main Gate is the only access for both civilians and military personnel onto post. Vehicles with identifying decals are quickly waived through the gate; however, visitors and truck traffic must show identification and other documents before being permitted to enter the post. The processing time slows vehicles entering the post.

The second factor involves the location of the gate. To the south, there is approximately 60 feet of storage per each of the two lanes between the gate and the intersection. This limited capacity to store vehicles waiting to be processed often causes vehicles to back into the intersection during the peak traffic periods. There is also only approximately 200 feet of storage between this intersection and the intersection with Porter Street along Ditto Avenue for vehicles exiting the installation. During PM peak hour data collection, queuing occurred through the Ditto/Porter intersection and along each of these roadways.

The third factor affecting gate operations is the volume of traffic entering the gate. During many instances, the volume of traffic entering the gate is so high that queues are inevitable and even speedy processing times would not alleviate them.

### **Intersection and Gate Operation Improvements**

In order to alleviate the queuing, the near-miss, and sight distance concerns, the following improvements are recommended (Figure 8):

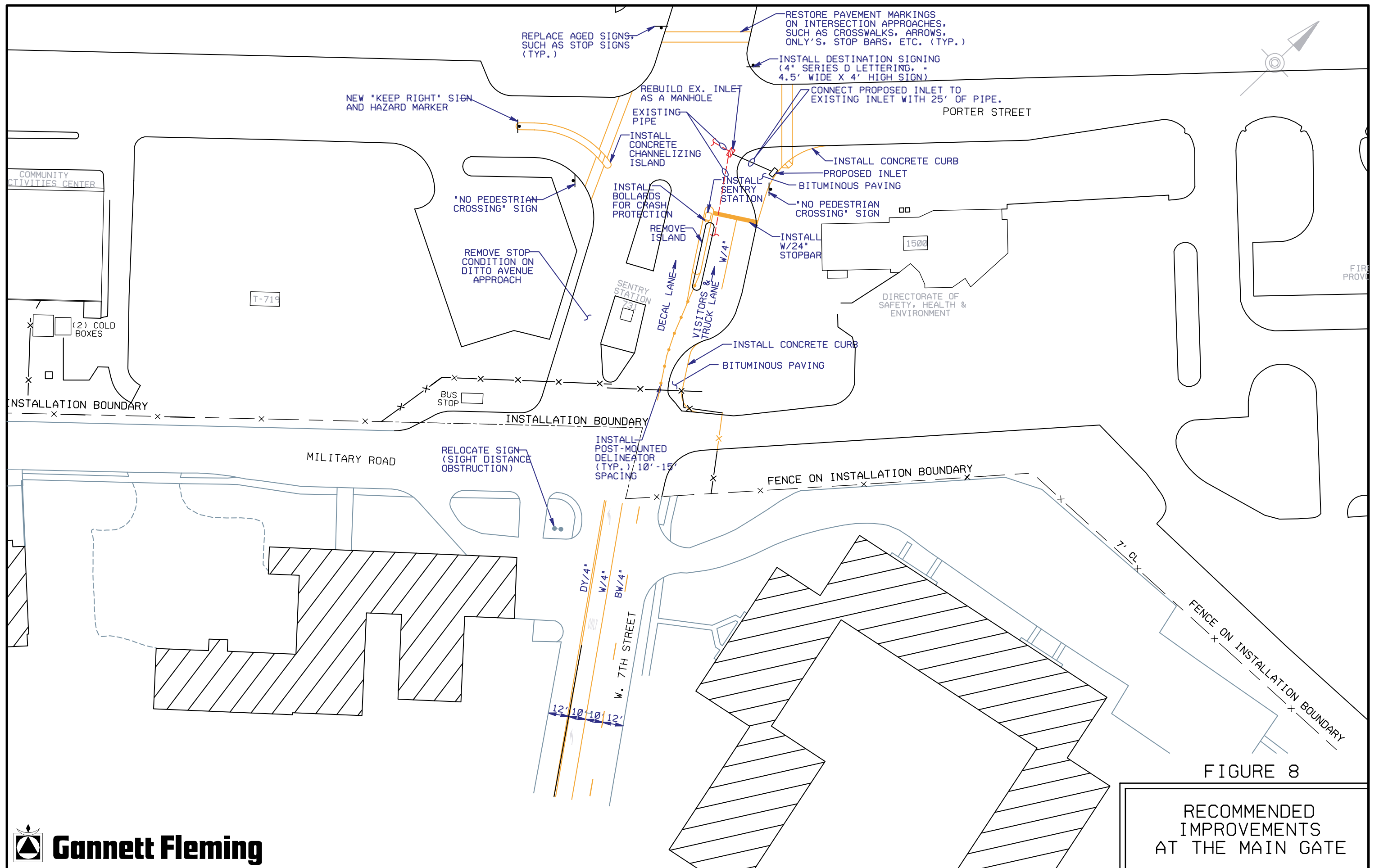
- Revise advanced signing on 7<sup>th</sup> Street and Military Road as per Figure 7. The estimated cost of this improvement is \$8,000.
- Revise the gate operation to two sentry stations:
  1. The large, existing sentry station in the median island to monitor and wave motorists with decals through the intersection. Vehicles with decals will continue to use the inside lane.
  2. Remove the existing island along Northbound Ditto Avenue and construct a new island with a sentry station for easy access to the driver's side of visiting truck

traffic and visitors. Truck traffic and visitors will be channeled to the right lane of the entrance.

The estimated cost of these improvements is \$16,000.

- Remove the stop condition on Ditto Avenue.
- Provide a separate left turn lane on the 7<sup>th</sup> Street approach. The estimated cost of this improvement is \$1,100.
- Replace the overhead lane use control signs and the stop sign on the Military Road approach. Replace any other roadway signs that have lost their nighttime reflectivity on the approaches to the intersection as routine maintenance. The estimated cost of this improvement is \$1,000.
- Replace the existing Ditto Avenue approach pavement markings (symbols, legends, lane line) with thermoplastic pavement markings. Thermoplastic pavement markings will provide greater visibility, reflectivity, and longevity needed for a twenty-four hour gate. The estimated cost of this improvement is \$1,000.





## Intersection of Ditto Avenue and Porter Street

### Existing Conditions:

- **Control:** Unsignalized intersection with three-way STOP control on the southbound, eastbound, and westbound approaches. Northbound (entering) traffic is free-flowing.
- **Speed Limit:** 25 mph on all approaches.
- **Roadside Hazards:** None.
- **Sight-distance Restrictions:** None.
- **Lighting:** Northeast and southwest quadrants.
- **Morning Peak-hour Traffic:** Total intersection volume of 1,069 vehicles (refer to fig 4 for turning movement counts).
- **Mid-day Peak-hour Traffic:** Total intersection volume of 1,133 vehicles (refer to fig 4 for turning movement counts).
- **Evening Peak-hour Traffic:** Total intersection volume of 1,069 vehicles (refer to fig 4 for turning movement counts).
- **Pedestrian Level:** Minimal (less than 2 per hour).
- **Restrictions:** Between 6:00 am and 6:00 pm, the eastbound approach on Porter Street is restricted to right turns only (Figure 11).
- **One-year (January 1999 - December 1999) Crash History:** 4 crashes, no injuries or fatalities.

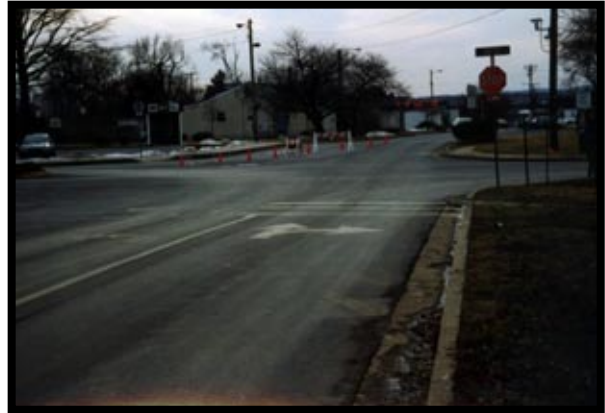


Figure 9. Intersection of Ditto Avenue and Porter Street (westward view).



Figure 10. Temporary channelization of eastbound vehicles on Ditto Avenue at Porter Street.

**Discussion and Recommendations:**

Ditto Avenue and Porter Street form a four-legged, three-way stop controlled intersection approximately 200 feet inside the Main Gate. Vehicles entering the post along northbound Ditto Avenue free flow through the intersection, while the remaining approaches must stop.

- **Intersection Operations**

Due to the unusual intersection control and the direct impact of the adjacent intersection on its operation, the Ditto/Porter intersection was analyzed in system using *Synchro* and *SimTraffic*. The results of the analyses are contained in Appendix A. Although the control of the Ditto/Porter intersection was not changed, the improvements to the Military/Ditto/7<sup>th</sup> intersection reduced the total delay at the intersection from 107.3 hours of delay to 1.8 hours of delay in the PM peak hour.

- **Signing and Marking**

While generally the signing and pavement markings are adequate, the following deficiencies were noted:

1. Due to the free-flow of traffic entering the installation, it is unsafe for pedestrians to cross the south side of the intersection. Two “No Pedestrian Crossing” signs (R3-9a, 18” x 18”) should be provided on the south side of the intersection (Figure 11).
2. The 3-way placard supplementing the stop signs are not standard (Figure 12). The 3-way placard should have a white border and the lettering should be in accordance with the MUTCD. The R1-3, 3-WAY plate, is the standard sign.
3. The time-specific restriction for right turns only on the eastbound approach does not control all vehicles and is maintenance intensive.
4. Many of the pavement markings are faded and may be difficult to view under wet conditions.



Figure 11. R9-3a No Pedestrian Crossing sign.



Figure 12. Improper 3-way placard (southward view).

### **Intersection Improvements**

Based on the field observations, as well as the analyses presented above, the following improvements were identified to improve safety at the intersection:

- Install permanent concrete channelizing island on the eastbound approach. Estimated cost for this improvement is \$3,400.
- ADA ramps should be added at the northern crosswalk on the northeast corner of the intersection. Estimated cost for this improvement is \$1,000.
- Install R9-3a “No Pedestrian Crossing” signs to the south side of the intersection. The estimated cost of this improvement is \$300.
- Replace stop signs and 3-way placards on all approaches. The estimated cost of this improvement is \$1,000.
- Replace worn pavement markings on all approaches to the intersection. The markings include word markings, symbol markings, stop bars, lane lines, and centerlines. The materials and application of the markings should meet state or local specifications to ensure proper reflectivity and durability. The estimated cost of this improvement is \$1,000.

### **Truck Routing**

Besides the curb radius in the southeast quadrant of the Ditto and Porter intersection, no specific deficiencies or challenges were noted due to truck traffic during field observations of the Main Gate area. While the newly constructed Old Farm Gate has the optimum geometrics for handling truck traffic, the Main Gate with minor modifications may handle the truck traffic adequately. Improved destination signing and street name signing will help alleviate confusion for truck drivers and other visitors to the post.

## Safety Audit

As part of this study, a safety audit was conducted on primary and secondary post roadways. Ditto Avenue, Porter Street, Doughten Drive, Stark Street, Ware Drive, and Chandler Street were analyzed as well as other installation roadways. The purpose of this task was to identify common safety deficiencies on the roadways. For the purpose of this study, the criteria set forth in the *AASHTO Roadside Design Guide* and the *MUTCD* was used as a guide in determining safety deficiencies.

The following provides some examples of roadside safety deficiencies that were noted during field observations. It should be noted that this audit provides a general overview of safety conditions and does not detail all roadway deficiencies.

- **Fixed Objects** - The *Roadside Design Guide* recommends clear zones (clear zone is the total roadside recovery area, starting at the edge of traveled way, safe for errant vehicles) for roadways dependent on speed, ADT and slope. Generally, clear zones range from 7 to 30 feet. For the most part, clear zones along installation roadways appear to be acceptable; however, there are some locations throughout the installation that may not be in compliance with the requirements.



Figure 13. Fixed objects in the clear zone at the intersection of Gardner and Sultan (eastward view).

All signs that are placed in the clear zone should be of a suitable breakaway or yielding design. Objects, such as the posts shown in Figure 13 should be removed or relocated outside the clear zone, if possible. Utility poles are located within the clear zone at some locations. This situation was noted particularly along Doughten Drive, where a number of utility poles are approximately 4-foot from the edge of roadway (Figure 14).



Figure 14. Utility poles in clear zone; Non-standard single, yellow center line; no edge lines; and angle on-street parking along Doughten Drive (northward view).

- **Drainage** – Drainage structures should be in conformance with clear zone guidelines as well. Additionally, drainage inlets should be constructed in conformance with current guidelines. Most drainage facilities appear to be in conformance with *AASHTO* guidelines.



- **Slopes** – Steep slopes present within the clear zone should be protected with guiderail. Figure 15 illustrates a steep drop off into a drainage ditch along Sultan Drive.



Figure 15. Ditch within clear zone along Sultan Drive (westward view).

- **Pavement Markings** – The pavement markings generally appear to be poorly maintained. In most instances, pavement markings should be reapplied every six months in order to meet acceptable visibility standards.

Many of the post roadways are marked with a single, solid, yellow center line or no center line at all. A single, solid, yellow center line is not a standard pavement marking. On two-lane, two-way roadways which are 16 feet or more in width, a center line is recommended. Improper or inadequate pavement markings are a tremendous source of liability.

Edge lines are extremely beneficial at keeping a motorist on the roadway. For roadway widths of 20 feet or more, edge lines are recommended. Ditto Street, north of Starks Road, should have white edge lines delineating the edge of the traveled way.

- **Signs** – The use of signs on post is generally in conformance with *MUTCD* guidelines. Some specific items of note are:

1. Check the height of signs to be sure the bottom of the sign is 7 feet above the ground in areas with curbing. In an open section, the bottom of the sign must be at least 5 feet above the level of the edge of roadway. Refer to Figure 2-1 of the *MUTCD*.
2. Use standard signs. For example, the deer warning sign on Porter Street is non-standard. Figure 16 shows a standard deer warning sign.
3. Proper signing of one-way streets. Refer to Figure 2-4 of the *MUTCD* for proper signing standards.



Figure 16. W11-3 Deer Warning Sign.

4. Unrelated signs should not be mounted on the same sign post. For example, see Figure 17.



Figure 17. Unrelated, non-standard signs on the same post on Ditto Avenue (northward view).

- **Lane Transitions** – An inadequate lane transition along Ditto Road, immediately north of Porter Street, is pictured in Figure 18. The transition from two lanes to one lane is only 36 feet in length. According to the MUTCD, the transition should be a minimum of 115 feet (assuming an 11-foot lane width), following the formula:

$$L = WS^2 / 60, \text{ where:}$$

L = length of transition in feet (in feet);  
W = width of lane to be dropped (in feet);  
S = posted speed limit (in miles per hour).



Figure 18. Lane drop transition on northbound Ditto Avenue.

- **On-street parking** – Angled on-street parking may potentially cause vehicular conflicts, as vehicles back from a parking space into the travel lane. In the future, parallel on-street parking or off-street parking should be considered (refer to Figure 14).

# **Appendix A SimTraffic Summary of MOE's**



**Measures-of-Effectiveness at the Intersection of Ditto Avenue and Porter Road**

Movement	AM Peak		Mid-day Peak		PM Peak	
	Existing	Proposed	Existing	Proposed	Existing	Proposed
Delay per Vehicle (seconds/vehicle)	4.0	3.9	6.0	5.3	421.3	5.7
Total Delay (hours)	1.2	1.2	1.9	1.7	107.3	1.8
Fuel Used (gallons)	5.3	4.9	6.7	6.1	57.8	6.2

**Measures-of-Effectiveness at the Intersection of 7<sup>th</sup> Street/Ditto Avenue and Military Road**

Movement	AM Peak		Mid-day Peak		PM Peak	
	Existing	Proposed	Existing	Proposed	Existing	Proposed
Delay per Vehicle (seconds/vehicle)	3.3	2.7	6.9	4.0	17.1	9.5
Total Delay (hours)	1.2	1.0	2.7	1.6	6.5	4.1
Fuel Used (gallons)	13.8	15.6	13.3	15.6	13.8	15.4

# **Appendix B Benefit-Cost Analysis**

Improvement	Expected Result	Initial improvement Cost	Annualized Improvement Cost (1)	improvement Life (Years)	Reduction Factor	Accident Damage Addressed			Annual Monetary Benefit (1)	B/C Ratio
						PROPERTY	INJURY	FATAL		
MILITARY ROAD, 7TH STREET, & DITTO AVENUE										
Revise 7th Street advanced signing (4)	Reduce driver confusion	\$8,000	\$986	10	0.075	1	0	0	\$900	0.91
Revise gate operation	Reduce delay and improve safety	\$16,000	\$1,177	20	0.250	1	0	0	\$3,000	2.55
Remove stop condition on Ditto Avenue	Reduce delay and improve safety	\$500	\$62	10	0.500	1	0	0	\$6,000	97.33
Provide separate turn lane on 7th Street (2)	Reduce delay and improve safety	\$1,100	\$81	20	0.350	1	0	0	\$4,200	51.89
Perform routine sign maintenance	Reduce driver confusion	\$1,000	\$225	5	0.100	1	0	0	\$1,200	5.34
Improve/replace pavement markings (2)	Reduce driver confusion	\$1,000	\$530	2	0.100	1	0	0	\$1,200	2.26
DITTO AVENUE & PORTER STREET										
Install permanent concrete island	Reduce vehicular conflicts	\$3,400	\$306	15	1.000	1	0	0	\$12,000	39.24
Install No Pedestrian Crossing signs (3)	Improve Pedestrian safety	\$300	\$67	5	0.100	0	0.3	0	\$630	9.35
Perform routine sign maintenance	Reduce driver confusion	\$1,000	\$225	5	0.100	2	0	0	\$2,400	10.68
Improve/replace pavement markings	Reduce driver confusion	\$1,000	\$530	2	0.100	1	0	0	\$1,200	2.26

## NOTES:

1. ANNUAL RATE OF INFLATION ASSUMED TO BE 4 PERCENT
2. CRASHES NOTED ARE POTENTIAL CRASHES DUE TO OPERATIONAL CHANGE
3. CRASHES NOTED ARE POTENTIAL CRASHES DUE TO EXISTING DEFICIENCY
4. ALTHOUGH THE B/C RATIO IS LESS THAN 1.0, THE IMPROVEMENT WILL ALSO PROVIDE OPERATIONAL BENEFITS NOT INCLUDED IN THE CALCULATION.